# PRESSURE INVESTIGATIONS TO SUPPORT BIOLOGICAL INDEX TESTING

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## ABSTRACT

Most Federal Columbia River Power System (FCRPS) hydroturbines, located at mainstem Columbia and Snake River dams are near the end of their design operating lives. Over the next several years, the majority of these turbines will be repaired or replaced. A goal of the Corps' Turbine Survival Program is to develop data that will aid in development of hydroturbine designs and identification of turbine operations that will provide safer passage of juvenile migrants through FCRPS turbines.

During passage through hydroturbines, fish are at risk of injury from collision on structure; strike by turbine runner blades, exposure to shear, and exposure to changes in pressure. The changes in pressure are decompressive in nature and occur as the fish transits from the pressure to the suction side of turbine runner blades. The response of juvenile Chinook salmon to rapid decompression typical of that experienced during passage through FCRPS hydroturbines has been determined in this study. The report of these findings will be prepared as a design reference for hydroturbine engineers and will be a factor in Corps' biological index testing to optimize hydroturbine operations for safer passage of downstream migrants through the FCRPS.

Following validation of the assumption that river-run and hatchery juvenile Chinook show the same response to rapid decompression, a study was designed to systematically evaluate the response of depth acclimated subyearling and yearling sized hatchery Chinook salmon to rapid decompression. The dependent (response) variable for the study was mortal injury, a derived variable based on both fish injury and immediate mortality. The study independent (treatment) variables were acclimation pressure, nadir pressure, total dissolved gas level, and rate of change in pressure.

Following acclimation for 16 hours at selected depth equivalent absolute pressure, groups of seven fish, were exposed to simulated turbine passage time histories with selected nadir absolute pressures. Exposed fish were processed to determine the number in each group that suffered mortal injury. The resulting mortal injury data were analyzed to statistically evaluate the response of test fish to treatment factors. Analysis found that total dissolved gas level and rate of change in pressure did not explain a significant portion of the variability in mortal injury. Both acclimation pressure and nadir pressure were found to be significant treatment factors. Further analysis of the pressure data resulted in derivation of a metric, the natural logarithm of the ratio of acclimation and nadir pressures (LRP), which explained the majority of variability in mortal injury observations while permitting a reduction in the dimensionality of the study outcome space. Likelihood equations were fit to mortal injury by LRP data for subyearling and yearling sized hatchery juvenile Chinook. The resulting relationships are sigmoid in form, indicating very low risk of mortal injury when the ratio of acclimation and nadir pressures are small then increasing to a probability of mortal injury near 1.0 when the ratio of pressures is large.